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AUTHOR	Kenney, Michael, Ed.
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ABSTRACT

This publication issues a challenge to students to collect data in a nationwide analysis of water hardness. Background information on the chemistry of hard water is presented using a cartoon format, and each of the four activities contains an explanation about the chemistry illustrated in the activity. The effect of hard water on soap, the effect of calcium ions in water, the chemistry of a test strip, and the creation of a supersaturated solution are among the topics of the experiments. The publication also includes details about participation in the nationwide study and National Chemistry Week. (DDR)

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ED 423 112

Planet Chemistry

HANDS-ON ACTIVITIES FOR KIDS FROM ALL PLANETS

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

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SE 061602

Calling all kids who live, work, and play on this big ball floating in space that we call Planet Earth

We invite you to help with an experiment being done across the entire country. Using supplies from home, school, and this booklet, you can do an experiment and add your data to our nationwide analysis of water hardness.

Check out the activities in this booklet, and look closely on page 6 for details of this nationwide experiment.

PLANET CHEMISTRY

national

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WHAT? Your suds are duds?!

This is chemistry?
Whew! I feel like I'm pulling something really heavy
I wonder if Cheryl has noticed the tow rope yet?
And Greg LeMond thought the Pyrenees were tough
I thought we were going to do the Macarena
Jim is sure a good sport to play with us even though we stink
These guys sure are good. I'm really getting a super workout
Hee hee— don't Jim realize that his underwear is showing?
What style! what talent! what's wrong with my leg— I think it's stuck

Have you ever worked or played really hard?...

So hard that at the end of the day you're dripping sweat, you're dirty, disgusting, and some people even say you stink?

All you really need (and want) is a hot shower or bath with lots of sudsy soap bubbles. You grab your favorite bar of soap and jump in. The water is hot and you start to scrub, but —

Is that a mississippiensis I see in the water?
He doesn't have a clue who I am
What is that guy's name? Randy? Dan? Edmund?
TRAIL
Trail number 80, 81, 82, 83, 84, 85, 86...
She thinks I'm an alligator!

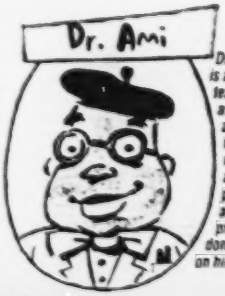
Your suds are duds! Your bubbles have troubles! Your soap has no hope!

What's going on?

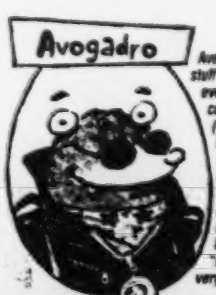
Your problem is not difficult—

Cast of Characters:

Ms. Screech is a strange and enthusiastic chemistry teacher. She always tries to get everyone involved and likes to keep close tabs on all her kids. She is very helpful and will make sure students clean up after themselves. She loves to garden and drive her little blue sporty convertible.



Dr. Ami is new and is a bit odd. He teaches science and art and his classes are never boring. He loves doing messy experiments and messier paintings. He is also a bit of a practical joker so don't turn your back on him.



Avogadro likes to count stuff— anything and everything. He has counted so many things, (more than a googol) that he is afraid of losing track. He recently started to count atoms and molecules and has named a new counting unit after himself— he calls it the "mole" and it is a very, very, very, large number.

Nancy recently moved from the neighborhood. She still stops by to play or do some chemistry once in a while and is always ready to lend a hand when needed. She loves dancing and alligators.

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Phew! Is that it or is Avogadro really stinky today?
Why do I always forget my towel?
Let's see, does it smell more like moldy rocks or Limburger cheese?
15,687, 15,688, 15,689, 15,690 stinky in this soccer ball

If you don't think duddy suds could happen to you, check out this experiment

Experiment #1

SUPPLIES: EPSOM SALTS, MEASURING SPOONS, A CUP, BAR OF SOAP

1. Mix 1 tablespoon of Epsom salts in 250 mL (1 cup) of warm tap water. Look on the label: it has magnesium sulfate—one of the main culprits (along with calcium carbonate) in **hard water**.
2. Now, grab a bar of soap and wash your hands. Be sure to make a good lather with lots of bubbles. Then, rinse your hands— get all the soap off them.
3. Ask a partner to pour some of the Epsom salts and water solution into your hands— now try making a lather with the bar of soap like you did before— YUK! Just a little magnesium sulfate can make a big difference.
4. Try mixing 1 teaspoon of Epsom salts with 1 cup of water, and see if you can make a lather.
5. What is the minimum amount of Epsom salts that you can mix with a cup of water and still not make a lather?

Note: Be sure to wash your hands with soap and tap water after finishing the experiment.

THE FACTS

What is Hard Water?

Water that has a hard time making a lather when it mixes with soap is called hard. Hard water contains a lot of calcium and/or magnesium that is picked up when the water flows over or through limestone or some other rock that has a lot of calcium or magnesium.

Soap contains long, chainlike molecules that have one end that interacts with water and another end that interacts with dirt and oil to remove them from your skin and clothes. When soap interacts with water, the end that interacts with dirt and oil spreads out, moving away from the water. That spreading is the bubbles that you see.

But if the water contains calcium or magnesium, the soap molecules interact with the calcium and the magnesium before they interact with the water, resulting in scum. Soap scum is soap molecules clumping together. As a result, the soap does not spread out like it does when it interacts with water. So, we can't make bubbles with hard water solutions.

Hard water is bad in your home because it combines with soap to make a scum or film that you can see as a bathtub ring or white crust on the showerhead. Soap scum also sticks to clothes making them look dirty.

Mike is the new guy and is trying to remember everybody's name. He's a nice guy but kind of klutzy. He likes all kinds of bugs and reading science fiction.

Shirley is always smiling. She knows everything and is always willing to lend a helping hand. She likes going to restaurants for dinner. She is especially helpful to the new kids—assisting them to get settled.

Jim lives in another neighborhood but still comes around to play and help out. He's very creative and is always coming up with wild new ideas for things to do. He likes dogs, cars, and his pet boa constrictor, Squeezum.

Cheryl is always there when you need a friend. She knows everyone. When she's not playing with the kids, she's talking on the phone to someone from another state. She loves to travel and has been to so many places that she's lost track. She recently learned she is moving and is real excited about the chance to make more friends.

Softened Water

If we really want to get our clothes or bodies clean with soap, we have to have water and bubbles. The more bubbles, the cleaner we get!

Let's do a simple experiment to see which makes more bubbles; hard or soft water. First, gather all the Supplies listed. Once you have everything, jump down to Experiment #2.

Zowie! That stuff bubbles more than that gross candy kids eat
Neat! It's kinda like that experiment we did in Dr. Ami's class mixing baking soda with vinegar
WATER SOFT
SOFTENER
VINEGAR

SUPPLIES:

- 2 LARGE CONTAINERS FOR MIXING, 1 L (4 CUPS)
- 2 CLEAR SODA BOTTLES WITH CAPS, ABOUT 600 mL (20 OZ.)
- SMALL PIECE OF CHALK— ABOUT 2.5 CM (1 IN.)
- WHITE VINEGAR
- COMMERCIALLY AVAILABLE WATER SOFTENER*
- LIQUID HAND SOAP (BE SURE TO USE SOAP AND NOT DETERGENT!**)
- MEASURING CUPS AND MEASURING SPOONS

*Check the laundry supply aisle at your grocery store.

**Detergent has chemicals called surfactants that make it possible to get bubbles in soft and hard water. Read the label and you will find phrases such as anionic or cationic surfactants. Be sure that you use soap for these activities.

Experiment #2

1. Using one of the large containers, dissolve the chalk in 30 mL (2 tablespoons) of vinegar. Let this sit for at least 10 minutes. Watch the solution. Record anything that you observe.

   _____

   _____

2. Add 750 mL (about 3 cups) of water to the dissolved chalk. *This is your artificial hard water solution; it contains dissolved calcium from the chalk.* Label this "Hard Water."
3. Using only one of the unused test strips from page 6, determine the hardness of your hard water solution (you will need the other strips for other experiments). Dip test strip into your water sample for 1 second. After waiting 15 seconds, compare the color on the strip with the colors on the reference chart on page 6. Record this value.

   Hard Water Solution _____
4. Put 250 mL (1 cup) of the artificial hard water solution into the other large container. (Be careful that any undissolved chalk is left in the hard water container.) Add 250 mL water and 4 tablespoons of water-softening agent. Stir well and wait for at least 10 minutes. (Don't worry if all of the water-softening agent does not dissolve.) *This is your softened water solution.* Label this "Soft Water."
5. Using a second test strip, determine the hardness of your softened water solution as you did in step 3. Record this value.

   Softened Water Solution _____
6. Now, test how easily you can make suds using the two solutions. Carefully add 250 mL of the artificial hard water solution to one of your empty soda bottles. Add 250 mL of softened water to the other soda bottle. Be sure to label the bottles. Add two drops of liquid hand soap to each bottle. Put caps on the bottles and shake them. Record your observations.

   _____

   _____

Did the artificial hard water solution make bubbles?_____

Did the softened water solution make bubbles?_____

Which solution made more bubbles?_____

In which solution did the bubbles last longer?_____

Thanks to:

CH
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125
YEARS
INNOVATION
TECHNOLOGY &
RESPONSIBLE CARE
AT WORK

Bubbles better!

Wow! These goggles are cool. Wonder where I can buy a pair for home?
I had op— nobody g to be able read this
That's Ann??? and the other one is Josh??? I'm so confused!
I bet he's trying to remember our names again. Hopeless!
Mike and Shirley think it's this one but I really think it's the orange one
It really doesn't seem to matter how much energy I expend shaking this— this hard water does not want to make bubbles
Shake shake shake Shake shake shake Shake your booty Shake your booty
I wonder if Shirley realizes that she is sticking out her tongue?
Let's see; 95,456,823 bubbles, 95,456,824 bubbles, 95,456,824 bubbles
HARD
SOFT

THE FACTS
What's Happening?

When you added vinegar to the chalk, you probably saw some bubbles. These bubbles formed because of a chemical reaction between the vinegar (acetic acid) and the chalk (calcium carbonate). This chemical reaction produces calcium ions (that's what makes water hard) and carbon dioxide gas (the bubbles you may have seen).

When you added the water-softening agent to the hard water solution, you added other chemicals that react very strongly with calcium ions and prevent the calcium from reacting with the soap. This means that the soap molecules can interact with the water to form bubbles.

To make suds, soap molecules must interact with other soap molecules. If a lot of soap molecules interact, you can make a lot of suds. The problem in a hard water solution is that soap molecules would rather interact with the calcium than with other soap molecules. So, hard water solutions don't make a lot of bubbles. By softening the water, you can make more bubbles. And, because soap suds interact better with dirt and oil, a water solution with a lot of bubbles does more cleaning.

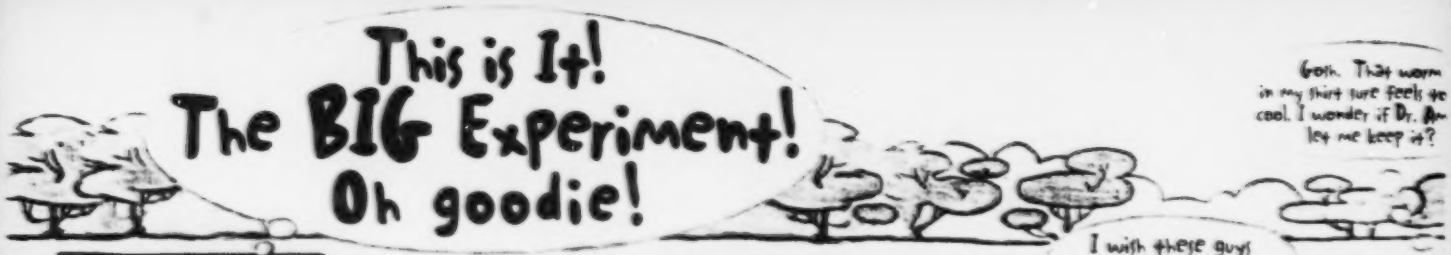
Another place you can find a lot of calcium is in milk. Do you think there will be a lot of bubbles if you mix some milk with some hand soap and shake it? Try it and see.

WONDERSCIENCE

Explore more fun and exciting hands-on science activities with the American Chemical Society's magazine! For magazine and subscription information, call 800-209-0423.

Kids & Chemistry

We've got more hands-on activities! For a free catalog contact the program at 202-872-4381, or e-mail: kids@acs.org



Now you are ready!

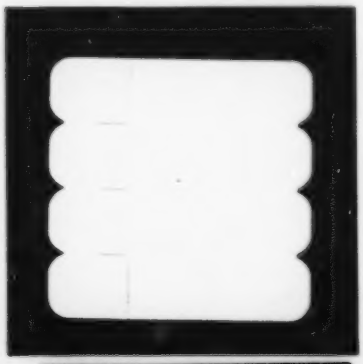
You've learned a little about hard water, water softening, and how to use the test strips. Now we need you to collect a sample of natural water (NOT tap water) and measure the hardness concentration. Send us the information about where you collected the water sample and the hardness concentration, and we will assemble all the data and share it with other correspondents. This activity will enlist the talents of thousands of individuals working to achieve a common goal—mapping water hardness across the United States. This type of experiment has never been done before and is an example of doing research on a grand scale.

Experiment #6

1. With the help of an adult volunteer, go out and collect a sample of water from a lake, stream, pond, river, ocean, well, or any other natural source. You don't need much; 1 cup (250 mL) will be plenty. **Do not use tap water!**
2. Using one of the two remaining test strips on this page, determine the hardness of your water sample. All you have to do is dip an unused test strip into your water sample for 1 second. After waiting 15 seconds for the color to develop, compare your test strip with the color chart below. Match the colors, and you will know the hardness concentration of your water sample.
3. Using this information, fill out the form at the bottom of page 7. Submit the data to us via the World Wide Web at **http://www.acs.org/ncw** (If you don't have Internet access, you can mail or fax the form to us. Our mailing address and fax number are on the form on page 7.)

We will use all of the data submitted to create a map that illustrates the hardness of natural water across the United States. You can view and download the map at **http://www.acs.org/ncw** on the Internet.

If you don't have access to the Internet, send us a self-addressed stamped business envelope, and we will send you a copy of the map that you can share with your parents, teacher, or keep for yourself.



COLOR CHART Dip the test strip in water for 1 second. Shake off the excess water. *Wait 15 seconds.* Compare color of test strip to color chart below.

0	50	120	250	425
Soft		Hard		Very Hard

THE FACTS For best results, use by 8/98.

The Chemistry of the Test Strip

On each test strip there is a chemical that reacts with calcium and magnesium to produce a new compound that is orange. If only a small amount of calcium or magnesium is in the test sample, only a small amount of orange chemical is produced. When the amount of calcium and/or magnesium increases, the orange chemical increases. The test strip indicates the amount of calcium and magnesium present in the solution by measuring the orange chemical produced.

Join us as we celebrate the 10th Anniversary of National Chemistry Week

10th Anniversary national

National Chemistry Week is the largest outreach program of the American Chemical Society and has been celebrated since 1987. In the past 10 years, volunteers across the country have spread the word that chemistry is fun and that everything is chemistry. Through hands-on activities, chemical demonstration programs, and a variety of other events, kids of all ages learn and do chemistry.

Chemistry looks FUN!
Hmmm. I wonder if it's safe leaning over like this with Cheryl behind me?
Nancy must be crazy leaning over the stream like this with me behind her.
I wonder when Jim will realize that I stuck a worm down his shirt?
Oh, go ahead Fishie, jump in
4,652,371,816 Fishies... lots of Fishies!

DATA FORM

Your Name (optional) _____

Your ZIP Code (needed) _____

Your Age (optional) _____

Source of water sample:

❑ Lake ❑ Stream/River ❑ Ocean ❑ Well ❑ Other

Concentration of hardness ions:

❑ 0 ❑ 50 ❑ 120 ❑ 250 ❑ 425

Submit on the WWW at:

http://www.acs.org/ncw

Or Mail to: **NCW— American Chemical Society, 1155 Sixteenth Street, NW, Washington, DC 20036**

Or Fax to: **202-833-7722**

Thanks for Your Help

Celebrate NCW

November 2–8, 1997

Rock formations called stalactites and stalagmites result when hard water drips from the ceiling of a cave. As the water evaporates, the calcium carbonate hardens. If the water drips slowly, a stalactite will form hanging from the roof of the cave and a stalagmite will form on the floor of the cave.

With the assistance of an adult volunteer, you can simulate the formation of stalactites and stalagmites by using Epsom salts.

STALAGMITES

Experiment #4

SUPPLIES: EPSOM SALTS, A CUP, GLASSES, PAPER CLIPS, UNWAXED COTTON STRING, ALUMINUM FOIL

1. Measure 2/3 cup of Epsom salts into 250 mL (1 cup) of hot tap water. *Be careful not to burn yourself.*
2. Divide the solution into two small glasses or jars. Put a large paper clip onto each end of a 30-cm (12-inch) piece of cotton string.
3. Soak the string for 5 minutes in one of the containers of Epsom salts solution.
4. After spreading foil on your work surface, hang the wet string between the two containers as illustrated.
5. After about 30 minutes, you should see a stalactite growing from the string and a stalagmite growing under the string. Leave the set-up overnight and look at the results in the morning.

Note: Be sure to wash your hands with soap and tap water after finishing the experiment.

THE FACTS
What's Happening?

The solution you made is supersaturated—there is more magnesium sulfate dissolved in the solution than should be possible at room temperature. How can that be?

Remember that we used hot water for this experiment. By using hot water instead of cold water, we were able to dissolve more magnesium sulfate. As the solution drips from the string, the water evaporates and the magnesium sulfate that remains solidifies and creates the stalactite and stalagmite. As the magnesium sulfate crystallizes, we see the results of the evaporation process.

You may be able to see this in your home on the showerhead. After the shower is turned off, hot water remains in and on the showerhead. As the drops cool, the chemicals crystallize leaving a white deposit. This is the same thing happening in the experiment above. Based on information contained in this booklet, how would you remove the deposits from the showerhead?

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EDITOR: Michael Kenney
ART DIRECTOR: Amy Meyer Phifer
COPY EDITOR: Beth Mitchell
ILLUSTRATOR: Dan Sherbo

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The activities described in this booklet are intended for school children under the direct supervision of adults. The American Chemical Society cannot be responsible for any accidents or injuries that may result from conducting the activities without proper supervision, from not specifically following directions, or from ignoring the cautions contained in the text.

All of the activities in this booklet have been reviewed for safety by Dr. Jack Breazeale, Safety Consultant, Mt. Pleasant, SC.